CBSE 12th 2024 Compartment Biology Set-3 (57/S/3) Solutions

SECTION A

Questions no. 1 to 16 are Multiple Choice Type Questions, carrying 1 mark each.

Q.1. The mosquito-borne disease in humans causing chronic inflammation of the lymphatic vessels is:
(A) Elephantiasis
(B) Ascariasis
(C) Ringworm
(D) Amoebiasis

Solution.(A) Elephantiasis, The mosquito-borne disease in humans that causes chronic inflammation of the lymphatic vessels is (A) Elephantiasis
Explanation:
Elephantiasis is caused by parasitic worms, particularly Wuchereria bancrofti, which are transmitted through mosquito bites. The infection leads to severe swelling and inflammation of the lymphatic vessels and nodes, often resulting in thickening and enlargement of the skin and underlying tissues, giving the appearance of elephant-like limbs.
Ascariasis is an intestinal infection caused by the roundworm Ascaris lumbricoides.
Ringworm is a fungal infection affecting the skin, hair, or nails, and is not related to mosquito bites or lymphatic inflammation.
Amoebiasis is an intestinal infection caused by the protozoan Entamoeba histolytica.

Thus, elephantiasis is the correct answer as it specifically involves lymphatic system inflammation caused by a mosquito-borne parasite.

Q.2. In plants, which one of the following helps in the absorption of phosphorus from soil ?
(A) Glomus
(C) Frankia
(B) Rhizobium
(D) Anabaena

Solution.(A) Glomus, In plants, the organism that helps in the absorption of phosphorus from the soil is (A) Glomus

Explanation:
Glomus is a genus of fungi that forms mycorrhizal associations with plant roots. These mycorrhizal fungi enhance the plant's ability to absorb phosphorus and other nutrients from the soil. They do this by extending their hyphae into the soil, which increases the surface area for nutrient uptake.
Rhizobium is a genus of bacteria that forms symbiotic relationships with legumes to fix atmospheric nitrogen into a form usable by plants, but it does not aid in phosphorus absorption.
Frankia is another type of nitrogen-fixing bacteria that forms symbiotic relationships with certain plants, especially actinorhizal plants, but is not involved in phosphorus absorption.
Anabaena is a genus of cyanobacteria (blue-green algae) that can fix nitrogen, often found in association with certain plants or in water bodies, but it is not involved in phosphorus absorption.
Thus, Glomus is the key player in enhancing phosphorus uptake from the soil for plants.

Q.3. Long ribbon-like pollen grains are seen in some :
(A) Aquatic plants
(B) Wind-pollinated grasses
(C) Gymnosperms
(D) Bird-pollinated flowers

Solution.(B) Wind-pollinated grasses The long ribbon-like pollen grains are commonly observed in (B) Wind-pollinated grasses

Explanation:

Aquatic plants typically have pollen that is adapted to floating or being carried by water.

Wind-pollinated grasses often have pollen grains that are long and ribbon-like to enhance their chances of being carried by the wind over long distances. This shape helps increase their surface area, which aids in their dispersal.

Gymnosperms and bird-pollinated flowers usually have different adaptations for pollen distribution, such as sticky or brightly colored pollen for the latter.

Thus, the characteristic long ribbon-like pollen grains are most commonly found in wind-pollinated grasses.

Q.4. Estrogen is secreted by :

(A) Corpus luteum

(B) Membrane granulosa of Graafian follicle

(C) Pituitary gland

(D) Germinal epithelium

Solution. (B) Membrane granulosa of Graafian follicle

Estrogen is primarily secreted by (B) Membrane granulosa of Graafian follicle

Explanation:

Corpus luteum: This structure produces estrogen, but it is more associated with the production of progesterone after ovulation.

Membrane granulosa of Graafian follicle: This is the primary site where estrogen is produced during the follicular phase of the menstrual cycle.

Pituitary gland: The pituitary gland produces hormones that regulate the production of estrogen but does not secrete estrogen itself.

Germinal epithelium: This is a layer of cells in the ovaries that is involved in producing eggs but does not secrete estrogen.

Therefore, the primary source of estrogen secretion is the granulosa cells of the Graafian follicle in the ovaries.

Q.5. Crystals of Bt toxin produced by some bacteria, do not kill the bacteria producing them because:
(A) bacteria are resistant to the toxin
(B) toxin is immature
(C) toxin is inactive
(D) bacteria encloses 'toxin' in a special capsule

Solution. (C) toxin is inactive, Crystals of Bt toxin produced by some bacteria do not kill the bacteria producing them because (C) toxin is inactive
Explanation:
Bt toxin (Bacillus thuringiensis toxin) is produced by certain bacteria in an inactive form, often as crystalline proteins. This form of the toxin is not toxic to the bacteria themselves.
The toxin becomes active only after it is ingested by target insects. Inside the insect's gut, the toxin is activated by the digestive enzymes, which then disrupt the gut cells and lead to the insect's death.
Bacteria are resistant to the toxin: While the bacteria themselves are indeed resistant to the toxin, the primary reason for this resistance is that the toxin is inactive until it is properly processed.
Toxin is immature: This is not correct. The toxin is produced in an inactive form, but it is not considered immature; it is simply not active until processed.
Bacteria encloses 'toxin' in a special capsule: This is not accurate. The bacteria do not enclose the toxin in a special capsule but rather produce it in an inactive form.
Therefore, the correct answer is that the toxin is inactive until it is processed in the digestive system of the target insect.

Q.6. The population interaction where one species is harmed and the other is unaffected is:
(A) Amensalism
(B) Commensalism
(C) Parasitism
(D) Predation

Solution.(A) Amensalism, The population interaction where one species is harmed and the other is unaffected is (A) Amensalism
Explanation:
Amensalism is an interaction where one species is harmed while the other species is neither helped nor harmed. An example of this is when a larger tree casts shade that inhibits the growth of smaller plants beneath it, but the tree itself is unaffected.
Commensalism involves one species benefiting while the other is unaffected. For example, birds nesting in trees benefit from the shelter while the tree is not affected.
Parasitism is where one species benefits at the expense of the other. For instance, a tapeworm benefits by living in the intestines of a host, which is harmed by the presence of the parasite.
Predation involves one species (the predator) benefiting by killing and consuming another species (the prey), which is harmed in the process.
So, the correct term for the interaction where one species is harmed and the other is unaffected is amensalism.

Q.7. The most primitive ancestor of humans is :
(A) Homo habilis
(B) Australopithecus
(C) Ramapithecus
(D) Homo neanderthalensis

Solution.(B) Australopithecus,The most primitive ancestor of humans among the given options is (B)Australopithecus
Explanation: Australopithecus is a genus of early hominins that lived between approximately 4 and 2 million years ago. It is considered one of the earliest ancestors in the human lineage and shows evidence of both bipedalism and arboreal adaptation.
Homo habilis is a later species in the human lineage, known for its use of tools, and is considered a more advanced ancestor compared to Australopithecus.

Ramapithecus is an early primate that lived around 12 to 14 million years ago and is thought to be more related to the early ancestors of apes rather than directly to humans.
Homo neanderthalensis (Neanderthals) are a more recent species that lived alongside early modern humans and are considered to be closer to modern humans than the more primitive ancestors.
Thus,Australopithecus represents one of the most primitive ancestors of humans among the choices provided.

Q.8 The sequence that controls the copy number of linked DNA in the vector is termed:
(A) Selectable marker
(B) Ori site
(C) Palindromic sequence
(D) Recognition site

Solution.(B) Ori site, The sequence that controls the copy number of linked DNA in the vector is termed (B) Ori site

Explanation:
Ori site (Origin of Replication): This is the sequence in a plasmid or vector where DNA replication begins. It controls how many copies of the plasmid are made within the cell, thereby influencing the copy number of the linked DNA.
Selectable marker: This is a gene included in a vector that allows for the selection of cells that contain the vector. It does not control the copy number.
Palindromic sequence: This refers to a sequence of DNA that reads the same forwards and backwards. It is often involved in the recognition sites for restriction enzymes but does not control copy number.
Recognition site: This is a specific sequence where restriction enzymes cut the DNA. It is crucial for cloning but does not control the copy number.
Thus, the Ori site is responsible for controlling the copy number of linked DNA in a vector.

Q.9. Which one of the following codons has dual function ?
(A) AUG
(B) AUC
(C) ACU
(D) ACA

Solution. (A) AUG The codon with dual function is AUG
Explanation:
AUG serves two important functions in protein synthesis:
1. Start Codon: It is the initiation codon that signals the start of protein synthesis.
2. Methionine Codon: It codes for the amino acid methionine in eukaryotes and bacteria.

AUC, ACU, and ACA are codons that only code for specific amino acids (Isoleucine, Threonine, and Threonine, respectively) and do not have the additional role of initiating protein synthesis.
Therefore, AUG is unique in that it both initiates the translation process and codes for an amino acid.

Q.10. Which one of the following options gives the correct temperature condition and the mixture of the gaseous components that were used by S.L. Miller in 1953 to prove abiogenesis of life ?
(A) CH4, H2, NO2 and water vapor at 1800°C
(B) CH4, H2, NH3 and water vapor at 1800°C
(C) CO2, H2, NH3 and water vapor at 800°C
(D) CH4, H2, NH3 and water vapor at 800°C

Solution.(B) CH4, H2, NH3 and water vapour at 1800°C
The correct temperature condition and mixture of gaseous components used by S.L. Miller in 1953 to simulate conditions for the abiogenesis of life is (B) CH4, H2, NH3 and water vapour at 1800°C**
Explanation:
S.L. Miller's Experiment In his famous experiment, Stanley Miller used a mixture of methane (CH_4), hydrogen (H_2), ammonia (NH_3), and water

vapour (H_2O) to simulate the early Earth's atmosphere. The experiment was conducted at a temperature around 1800°C (though often described around 100°C for the water vapour part of the setup) and involved passing electrical sparks through the gases to simulate lightning.

The goal was to demonstrate that organic compounds essential for life, such as amino acids, could form under prebiotic conditions. The successful synthesis of amino acids in the experiment supported the idea that the basic building blocks of life could arise naturally from simple molecules under early Earth conditions.

The other options do not match the conditions used in Miller's experiment.

Q.11. Amniocentesis is a technique that is used to:
(A) determine any disease of the heart
(B) determine any genetic disorder of the foetus
(C) determine any disorder of the brain
(D) detect any abnormality in the bone formation

Solution. (B) determine any genetic disorder of the fetus
Amniocentesis is a technique used to (B) determine any genetic disorder of the fetus
Explanation:
Amniocentesis is a prenatal diagnostic procedure where a small amount of amniotic fluid, which contains fetal cells, is extracted from the amniotic sac surrounding the fetus. This fluid is then analyzed for genetic abnormalities. It is primarily used to identify genetic disorders such as Down syndrome, cystic fibrosis, and other chromosomal abnormalities.
It is not used to determine diseases of the heart, brain disorders, or bone formation abnormalities directly, though it can provide information about genetic conditions that might affect these systems.

Q.12 In humans, non-disjunction of the 21 pair of chromosomes leads to :
(A) Acquired Immune Deficiency Syndrome

(B) Klinefelter's Syndrome
(C) Turner's Syndrome
(D) Down's Syndrome

Solution. (D) Down's Syndrome, In humans, nondisjunction of the 21st pair of chromosomes leads to (D) Down's Syndrome
Explanation:
Down's Syndrome (also known as Trisomy 21) occurs when there is an extra copy of chromosome 21 due to nondisjunction during cell division.
Acquired Immune Deficiency Syndrome (AIDS) is caused by the Human Immunodeficiency Virus (HIV) and is not related to chromosomal non-disjunction.
Klinefelter's Syndrome is a genetic condition in males caused by an extra X chromosome, resulting in an XXY karyotype.
Turner's Syndrome is a genetic condition in females caused by the absence of one X chromosome, resulting in an XO karyotype.
Thus, Down's Syndrome is the condition associated with nondisjunction of the 21st chromosome pair.

For Questions number 13 to 16, two statements are given - one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below.
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false, but Reason (R) is true.
13. Assertion (A): Streptococcus pneumoniae and Haemophilus influenzae are responsible for causing infectious diseases in human beings.
Reason (R): A healthy person acquires the infection by inhaling the droplets/aerosols released by an infected person.
14. Assertion (A): Biotechnology produces transgenic micro-organisms that act as microfactories for proteins.

Reason (R) : To produce proteins for human use like insulin, transgenic microorganisms can be developed.
15. Assertion (A): Gross primary productivity is always less than net primary productivity.
Reason (R) : Rate of synthesis of organic matter by consumers is known as secondary productivity.

For Questions number 13 to 16, two statements are given - one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below.
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false, but Reason (R) is true.

Q.13. Assertion (A): Streptococcus pneumoniae and Haemophilus influenzae are responsible for causing infectious diseases in human beings.
Reason (R): A healthy person acquires the infection by inhaling the droplets/aerosols released by an infected person.

Solution. Assertion (A): Streptococcus pneumoniae and Haemophilus influenzae are responsible for causing infectious diseases in human beings.
Reason (R): A healthy person acquires the infection by inhaling the droplets/aerosols released by an infected person.

The correct answer is:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
Explanation:

Assertion (A) is true. Both Streptococcus pneumoniae and Haemophilus influenzae are bacteria that cause infectious diseases in humans. Streptococcus pneumoniae is known for causing pneumonia and other respiratory infections, while Haemophilus influenzae can cause a range of infections including pneumonia and meningitis.
Reason ® is also true. These infections are commonly spread through respiratory droplets or aerosols. When an infected person coughs or sneezes, they release droplets containing the bacteria into the air, which can then be inhaled by a healthy person, leading to infection.
The reason correctly explains how these bacteria are transmitted and how infections are acquired, making both statements true and related.

Q.14. Assertion (A): Biotechnology produces transgenic microorganisms that act as microfactories for proteins.
Reason (R) : To produce proteins for human use like insulin, transgenic microorganisms can be developed.

Solution. Assertion (A): Biotechnology produces transgenic microorganisms that act as microfactories for proteins.
Reason (R): To produce proteins for human use like insulin, transgenic microorganisms can be developed.
The correct answer is:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
Explanation:
Assertion (A)is true. Biotechnology involves the creation of transgenic microorganisms, which are genetically modified to produce specific proteins. These microorganisms act as "microfactories" because they can produce large quantities of proteins through fermentation and other biotechnological processes.

Reason (R) is also true. Transgenic microorganisms are developed to produce proteins for human use, such as insulin, which is used in the treatment of diabetes. By inserting the gene for insulin into microorganisms,

these organisms can produce insulin, which is then purified and used for medical purposes.
The reason directly explains why biotechnology uses transgenic microorganisms, making both the assertion and the reason true and directly related.

Q.15. Assertion (A): Gross primary productivity is always less than net primary productivity.
Reason (R) : Rate of synthesis of organic matter by consumers is known as secondary productivity.

Solution. Assertion (A): Gross primary productivity is always less than net primary productivity.
Reason (R): Rate of synthesis of organic matter by consumers is known as secondary productivity.
The correct answer is (D) Assertion (A) is false, but Reason (R) is true.
Explanation:
Assertion (A): This statement is false. Gross Primary Productivity (GPP) is actually always greater than Net Primary Productivity (NPP). GPP represents the total amount of energy or biomass produced by primary producers (like plants) through photosynthesis. NPP is the amount of energy or biomass that remains after subtracting the energy used by the producers for their own respiration (R). Therefore, GPP = NPP + R. Since respiration consumes some of the energy, NPP is less than GPP.

Reason (R): This statement is true. Secondary productivity refers to the rate at which consumers (herbivores, carnivores, etc.) convert the organic matter they consume into their own biomass. It reflects how efficiently consumers are converting the energy from their food into new biomass.

Thus, the assertion is incorrect, while the reason is correct and accurately describes secondary productivity.

Q.16. Assertion (A): Periodic abstinence is a method in which couples avoid coitus from day 10 to 17 of the menstrual cycle.

Reason (R): Periodic abstinence has limited effectiveness because menstrual cycles are not always regular.

Solution. Assertion (A): Periodic abstinence is a method in which couples avoid coitus from day 10 to 17 of the menstrual cycle.
Reason (R): Periodic abstinence has limited effectiveness because menstrual cycles are not always regular.
The correct answer is:

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).
Explanation:
Assertion (A) is true. Periodic abstinence is a contraceptive method where couples avoid sexual intercourse during the period when ovulation is most likely to occur, which is typically from about day 10 to 17 of the menstrual cycle.
Reason (R) is also true. The effectiveness of periodic abstinence can be limited because menstrual cycles can vary in length and regularity, making it difficult to accurately predict the exact days of ovulation.
However, the reason provided does not directly explain why periodic abstinence involves avoiding coitus from day 10 to 17; it simply points out a limitation of the method. The method is based on the assumption that ovulation typically occurs around the middle of the cycle, but irregular cycles complicate its effectiveness.

SECTION B

Q.17. (a) Given below is a representation of the "Central dogma":
'A DNA B mRNA 'C' protein
Identify 'A', 'B' and 'C' in the above representation.

Solution. In the central dogma of molecular biology, the flow of genetic information is depicted as follows:
'A' DNA → 'B' mRNA → 'C' Protein

Here’s what 'A', 'B', and 'C' represent:
'A': DNA
DNA (Deoxyribonucleic Acid) is the genetic material that contains the instructions for the synthesis of proteins. It is the starting point of the central dogma.
'B': Transcription
Transcription is the process where the information in a specific segment of DNA is copied into mRNA (messenger RNA). This step involves synthesising mRNA from the DNA template.
'C': Translation
Translation is the process where the mRNA sequence is used to build a protein. During translation, ribosomes read the sequence of the mRNA and synthesise the corresponding protein by linking together the appropriate amino acids.
In summary:
'A': DNA
'B': Transcription (the process of making mRNA from DNA)
'C': Translation (the process of making proteins from mRNA)

(b) What does the Central dogma state in molecular biology? Write an example where it is not applicable.

Solution. Central Dogma of Molecular Biology
The Central Dogma molecular biology states the fundamental flow of genetic information within a biological system. It describes how genetic information is transferred from DNA to RNA and then to proteins. The basic sequence is:
1. DNA → mRNA (Transcription)
2. mRNA → Protein (Translation)
In simple terms, the central dogma posits that DNA is transcribed into messenger RNA (mRNA), and this mRNA is then translated into proteins, which perform various functions in the cell.
Example Where the Central Dogma Is Not Applicable
An example where the central dogma does not fully apply is in **reverse transcription:

Reverse Transcription: This process involves the conversion of RNA back into DNA. It is performed by an enzyme called reverse transcriptase. This is commonly seen in retroviruses, like HIV.
Example: HIV (Human Immunodeficiency Virus)
HIV is a retrovirus that carries its genetic information in the form of RNA. Once it infects a host cell, it uses reverse transcriptase to convert its RNA into DNA. This newly formed viral DNA is then integrated into the host cell's genome, which can then be transcribed and translated into new viral proteins. This process defies the traditional flow of information described by the central dogma because it goes from RNA to DNA, rather than the other way around.
In summary, the central dogma describes a unidirectional flow of genetic information (DNA → RNA → Protein), but reverse transcription represents an exception where RNA can be converted back into DNA.

Q.18. Why is making host cells 'competent' essential for rDNA technology? Mention any two ways by which this can be achieved.

Solution. Making host cells "competent" is essential in recombinant DNA (rDNA) technology because it enables the cells to take up foreign DNA. This process is crucial for inserting new genetic material into the host cells, allowing them to produce new proteins or exhibit new traits.

Why Competence is Essential:
DNA Uptake: Competent cells can efficiently take up recombinant DNA from their environment. Without this ability, the foreign DNA cannot enter the cells, and the subsequent genetic manipulation or protein production cannot occur.
Successful Transformation: Competence is a key step in the transformation process, where foreign DNA is introduced into the host cells to create genetically modified organisms.

Two Ways to Achieve Competence:
1. Chemical Transformation:

Method: Cells are treated with chemicals, such as calcium chloride, which makes their cell membranes more permeable to DNA.
Procedure: The cells are incubated with a solution of calcium chloride, followed by a heat shock step. The heat shock causes the cells to uptake the DNA through the now more permeable membrane.
Example: Commonly used with bacterial cells, such as E. coli.
2.Electroporation:
Method: Cells are exposed to an electric field that temporarily permeabilizes their membranes, allowing DNA to enter.
Procedure: A suspension of cells and DNA is subjected to a high-voltage electrical pulse. This pulse creates temporary pores in the cell membrane through which DNA can pass.
Example: Used with both bacterial and eukaryotic cells.

Both methods make the host cells capable of taking up recombinant DNA, which is a crucial step for various applications in genetic engineering and biotechnology.

Q.19. (a) Comment on the interaction between a fig tree and wasp. Mention the phenomenon that operates in their relationship.

Solution. The interaction between a fig tree and its associated wasp is a fascinating example of mutualism, a type of symbiotic relationship where both species benefit from the interaction.
Interaction Between Fig Tree and Wasp
Fig Tree (Ficus spp.): The fig tree produces specialised flowers inside a structure called a fig or syconium. These flowers are hidden inside the fig, making it a unique environment for pollination.
Wasp (Fig Wasp): Female fig wasps enter the fig through a small opening called the ostiole to lay their eggs inside the fig's flowers. While laying eggs, the wasps pollinate the fig flowers with pollen from other figs they have visited.
How the Interaction Works:
1. Pollination and Egg Laying:

The fig wasp enters the fig and deposits its eggs into the flowers inside.
The eggs hatch into larvae and develop within the fig's flowers.
As the wasp moves around inside the fig, it transfers pollen from previous figs to the female flowers within the fig, facilitating fertilization and ensuring that seeds can develop.
2.Development of Wasp Larvae:
The wasp larvae grow inside the fig, feeding on the flower tissues. Once they mature, the male wasps mate with the female wasps and then tunnel out of the fig, while the female wasps leave to find a new fig to lay their eggs.
3. Fig Benefits:
The fig tree benefits from the wasp's activities because the wasps provide essential pollination services that enable the fig tree to produce seeds and reproduce.

4.Wasp Benefits:
The wasps benefit by having a safe environment to lay their eggs and a food source for their larvae.
Phenomenon Operating in Their Relationship:
Mutualism: This relationship is a classic example of mutualism, where both species gain benefits. The fig tree gets pollinated, which is necessary for seed production, while the wasp gets a place to reproduce and feed its larvae. This mutualistic interaction is often highly specific, with each fig species having its own dedicated wasp species.
In summary, the interaction between a fig tree and a fig wasp exemplifies mutualism, where both the fig tree and the wasp benefit from their close association.

OR
(b) Explain "brood parasitism" with the help of an example.

Solution. Brood parasitism is a type of reproductive strategy where one species, known as the brood parasite, relies on another species to care for its offspring. The brood parasite lays its eggs in the nests of other species,

leaving the responsibility of incubating and feeding the eggs and young to the host species.

How Brood Parasitism Works:

1. Egg Laying:

The brood parasite, typically a bird, lays its eggs in the nest of a different bird species. The host bird then incubates the eggs, often unaware that they are not its own.

2. Chick Development:

Once the eggs hatch, the chicks of the brood parasite usually grow faster and may outcompete the host's own chicks for food. In some cases, the brood parasite chicks may even eject the host's eggs or chicks from the nest to reduce competition.

3.Host Care:

The host bird continues to care for and feed the parasitic chicks as if they were its own, investing time and energy in raising them.

Example of Brood Parasitism:

Common Cuckoo (Cuculus canorus):

Brood Parasitism Strategy:

The female common cuckoo lays her eggs in the nests of other bird species, such as reed warblers or meadow pipits.

Behaviour:

Cuckoo eggs often mimic the appearance of the host’s eggs, reducing the likelihood of the host recognizing and rejecting them.

Chick Development:

When the cuckoo eggs hatch, the cuckoo chicks typically grow faster than the host’s chicks. They may push the host’s eggs or chicks out of the nest to ensure they receive all the food provided by the host parents.

Impact on Host:

The host birds invest their resources in raising the cuckoo chicks, often at the expense of their own offspring.

Key Points:

Parasitic Benefit: The brood parasite benefits from the host’s parental care without investing in the costs of rearing its own young.

Host Cost: The host birds may experience reduced reproductive success because their own eggs or chicks are displaced or neglected.
In summary, brood parasitism is a strategy where a species exploits another species to raise its young. The common cuckoo is a well-known example, using the nests of other birds to incubate and rear its chicks while avoiding the costs of parenting.

Q.20. State the cellular nature and functions of myometrium and endometrium.

Solution. The myometrium and endometrium are two important layers of the uterine wall with distinct cellular structures and functions.
Myometrium:
Cellular Nature:
The myometrium is the thick, middle layer of the uterine wall.
It is composed mainly of smooth muscle cells (myocytes) that are interlaced with connective tissue. These smooth muscle cells are responsible for the contractile activity of the uterus.
Functions:
Contraction: The myometrium plays a crucial role in labour and childbirth. During labour, the smooth muscle cells contract to help push the baby out of the uterus.
Menstrual Cramping: It also causes menstrual cramps due to rhythmic contractions during the menstrual cycle.
Support: Provides structural support to the uterus and helps maintain its shape.
Endometrium:
Cellular Nature:
The endometrium is the innermost layer of the uterine wall.
It consists of a mucous membrane that includes an epithelial layer (containing columnar epithelial cells) and a stroma with connective tissue and blood vessels. It is rich in glandular structures.
Functions:

Menstrual Cycle: The endometrium undergoes cyclical changes during the menstrual cycle, thickening to prepare for potential implantation of a fertilised egg and shedding if implantation does not occur.
Implantation:Provides the site for the implantation of a fertilised egg (embryo). If implantation occurs, the embryo embeds into the endometrium, and the layer supports the developing foetus during pregnancy.
Nutrient Exchange: Supplies nutrients to the developing embryo through a network of blood vessels and glands.
In summary:
Myometrium: Smooth muscle layer, involved in uterine contractions and structural support.
Endometrium: Mucous membrane, involved in menstrual cycle regulation, implantation, and nutrient exchange.

Q.21. How do 'implants' act as an effective method of contraception in human females? Mention their one advantage over contraceptive pills.

Solution. Implants are a form of long-acting reversible contraception used in human females. Here's how they work and their advantages over contraceptive pills:
How Implants Work:
Placement: Implants are small, flexible rods or capsules that are placed under the skin of a woman's arm by a healthcare provider.
Hormone Release: These implants release hormones (typically progestin) slowly over time into the bloodstream.
Mechanism of Action:
Inhibition of Ovulation: The hormones prevent the ovaries from releasing eggs (ovulation).
Thickening of Cervical Mucus: The hormones also thicken the mucus in the cervix, making it difficult for sperm to enter the uterus and reach any eggs that might have been released.
Altering the Endometrium: The hormone can also alter the lining of the uterus (endometrium), making it less suitable for implantation of a fertilised egg.

Advantage Over Contraceptive Pills:
One Major Advantage: Long-Term Effectiveness: Implants provide long-term contraception (usually 3 to 5 years) with a single insertion, eliminating the need for daily adherence, which is required with contraceptive pills.
Consistency: Since implants work for several years once placed, they offer a "set and forget" method. In contrast, contraceptive pills require daily intake at the same time to be effective, which can be challenging for some women to maintain consistently.
Overall, implants offer a high level of convenience and reliability for contraception with less need for daily action compared to contraceptive pills.

SECTION C

Q.22. Differentiate between :
(a) Grazing food chain and Detritus food chain (Any three differences)

Solution. Grazing Food Chain vs. Detritus Food Chain
1. Starting Point:
Grazing Food Chain:
Starts with Green Plants: This food chain begins with primary producers, which are green plants or algae that convert solar energy into chemical energy through photosynthesis.
Example: Sun → Grass → Herbivore (e.g., rabbit) → Carnivore (e.g., fox).
Detritus Food Chain:
Starts with Dead Organic Matter: This food chain begins with decomposing organic matter or detritus, which is made up of dead plants, animals, and other organic materials.
Example:Dead Leaves → Detritus Feeder (e.g., earthworm) → Decomposer (e.g., bacteria) → Microorganisms.
2.Energy Flow:
Grazing Food Chain:

Direct Energy Transfer:Energy flows from the sun to plants (primary producers) and then to herbivores (primary consumers) and carnivores (secondary and tertiary consumers).
Typical Flow: Sunlight → Plants → Herbivores → Carnivores.
Detritus Food Chain:
Indirect Energy Transfer: Energy flows from the breakdown of dead organic matter through detritivores (organisms that feed on detritus) and decomposers to higher levels in the food chain.
Typical Flow: Dead Organic Matter → Detritivores → Decomposers → Secondary Consumers.
3.Role in Ecosystem:
Grazing Food Chain:
Primary Role: This chain is important for energy transfer in ecosystems where primary production (photosynthesis) is high. It's crucial in ecosystems like grasslands and forests.
Function: Transfers energy from sunlight to various trophic levels (producers to consumers).
Detritus Food Chain:
Primary Role:This chain is significant in recycling nutrients in ecosystems where dead organic matter is abundant, such as in forest floors and aquatic systems.
Function:Decomposes dead matter and recycles nutrients back into the ecosystem, making them available for primary producers.
Summary:
1.Starting Point: Grazing food chains start with green plants, while detritus food chains start with dead organic matter.
2.Energy Flow: Grazing food chains transfer energy from sunlight through various consumers, while detritus food chains recycle energy from decomposing matter through detritivores and decomposers.
3.Ecosystem Role: Grazing food chains are important in systems with active primary production, while detritus food chains are crucial for nutrient recycling in systems rich in dead organic material.

(b) Upright pyramid and Inverted pyramid (Any three differences)

Solution. Upright Pyramid vs. Inverted Pyramid
1. Shape and Structure:
Upright Pyramid:
Shape: The pyramid shape is upright or right-side up, where the base is broader and the apex (top) is narrower.
Structure:This type of pyramid represents a typical food chain structure where the number of organisms or biomass decreases as you move up from producers to top consumers.
Inverted Pyramid:
Shape: The pyramid shape is inverted or upside down, with the apex at the bottom and the base at the top.
Structure:This type of pyramid represents an ecological system where the number of organisms or biomass increases as you move up the trophic levels.
2. Representation of Numbers:
Upright Pyramid:
Numbers:In an upright pyramid of numbers, there are generally more individuals at the lower trophic levels (producers) and fewer individuals at higher levels (consumers).
Example:Grass → Herbivores (e.g., insects) → Carnivores (e.g., birds).
Inverted Pyramid:
Numbers: In an inverted pyramid of numbers, there are fewer individuals at the lower trophic levels and more individuals at higher levels.
Example: In some aquatic ecosystems, a large number of small phytoplankton (producers) might support fewer, but much larger, consumers like zooplankton.
3.Representation of Biomass:
Upright Pyramid:
Biomass: In an upright pyramid of biomass, the biomass (total weight of organisms) decreases as you move from producers to top consumers.
Example:Forest ecosystem with a large biomass of plants, less biomass in herbivores, and even less in top predators.

Inverted Pyramid:
Biomass: In an inverted pyramid of biomass, the biomass at the producer level may be less than the biomass at higher trophic levels.
Example: In some aquatic systems, a large number of small, rapidly reproducing phytoplankton may have a small total biomass compared to the higher biomass of fish that feed on them.
Summary:
1. Shape and Structure: The upright pyramid has a broad base and narrows upwards, while the inverted pyramid has a narrow base and broadens upwards.
2.Representation of Numbers:The upright pyramid shows more individuals at lower levels and fewer at higher levels, whereas the inverted pyramid shows fewer individuals at lower levels and more at higher levels.
3.Representation of Biomass: The upright pyramid shows decreasing biomass from base to top, while the inverted pyramid shows increasing biomass from base to top.

This comparison helps illustrate how different ecosystems can be represented in terms of numbers and biomass at various trophic levels.

Q.23. (a) (i) What are "biodiversity hotspot" regions? Mention any two criteria used for determining any region as a "hotspot".

Solution. Biodiversity hotspots are regions that are both rich in species and have experienced significant habitat loss. They are crucial for conservation efforts because they contain a large number of unique and threatened species. Here's a breakdown of what makes a region a "biodiversity hotspot" and the criteria used to identify these regions:

Biodiversity hotspots are areas that have exceptionally high levels of species richness and endemism but are also under significant threat from human activities. These regions are important for conservation because protecting them helps preserve a large number of species, many of which may be found nowhere else.

Criteria for Determining a Biodiversity Hotspot

To be classified as a biodiversity hotspot, a region must meet specific criteria:
1. High Levels of Endemic Species:
Definition: Endemic species are those that are found only in a particular geographic area and nowhere else in the world. A hotspot must contain a high number of these species, meaning the area has a significant concentration of unique and often irreplaceable flora and fauna.
Example:The Madagascar and the Indian Ocean Islands hotspot has many species that are found only in that region.

2.Significant Habitat Loss:
Definition: A hotspot must have experienced substantial loss of its natural habitat, often due to human activities such as deforestation, urbanisation, or agriculture. This loss is a key indicator of the urgent need for conservation.
Example: The Western Ghats in India and Sri Lanka have lost a significant portion of their original forest cover due to agricultural expansion and logging.
Summary:
Biodiversity Hotspots are regions with high levels of species richness and endemism that face significant threats from human activities.
Criteria for Identification:
1.High Levels of Endemic Species:The region must have a large number of species found nowhere else.
2.Significant Habitat Loss:The region must have experienced a substantial loss of its natural habitat.
These criteria help identify areas that are crucial for conservation efforts to protect the world's biodiversity.

(ii) Name any two hotspots of India.

Solution. In India, two notable biodiversity hotspots are:

1. Western Ghats:
Location: Stretches along the western coast of India from Gujarat to Kerala.
Significance: The Western Ghats are renowned for their rich biodiversity, including numerous endemic species of plants, animals, and fungi. They are a key area for conservation due to their high levels of species richness and ongoing habitat loss.

2.Eastern Himalayas:
Location: Covers parts of northeastern India, including states like Sikkim, Arunachal Pradesh, and parts of Assam.
Significance: The Eastern Himalayas are known for their incredible diversity of flora and fauna, with many species found only in this region. The area includes diverse ecosystems ranging from tropical forests to alpine meadows.

Both of these hotspots are crucial for protecting India's unique and diverse wildlife and plant species.

OR
(b) Explain three reasons why tropics show the greatest level of species diversity.

Solution. Tropical regions, such as the Amazon rainforest and the forests of Southeast Asia, are known for their exceptionally high levels of species diversity. Here are three key reasons why the tropics show the greatest level of species diversity:

1.Stable Climate:
Reason: The tropics have a relatively stable climate throughout the year, with minimal seasonal variation in temperature and consistent rainfall. This stability provides a reliable environment for species to thrive and evolve.
Effect:The stable conditions allow for a long period of evolutionary time without extreme disruptions, leading to the development of a large number of specialised species. Stable environments promote high biodiversity because species can adapt to their specific niches over long periods.

2. High Primary Productivity:
Reason: Tropical regions typically have high levels of primary productivity, meaning that they produce a large amount of biomass through photosynthesis. This is due to ample sunlight and abundant rainfall.
Effect: High primary productivity supports a wide variety of plant species, which in turn supports diverse herbivores, predators, and other organisms. The abundance of resources allows for complex food webs and numerous ecological niches, leading to greater species diversity.

3.Complex Habitats and Structures:

Reason:Tropical ecosystems, such as rainforests, have complex and varied habitats, including multiple layers (e.g., canopy, understory, forest floor) and a high level of structural complexity.
Effect: This complexity creates many different microhabitats and niches, allowing a diverse array of species to coexist. For example, different animals and plants can occupy different layers of the forest or use different resources, leading to high levels of species specialisation and diversity.
Summary:
1.Stable Climate:Consistent conditions promote long-term evolutionary processes and specialised adaptations.
2.High Primary Productivity: Abundant resources support diverse plant and animal life.
3.Complex Habitats: Varied and intricate environments create numerous ecological niches.
These factors together create an environment where a vast number of species can thrive and evolve, contributing to the exceptional biodiversity found in tropical regions.

Q.25. (a) What is gene therapy ?

Solution. Gene therapy is a medical technique aimed at treating or preventing diseases by altering the genes within a person's cells. Here’s a straightforward explanation:

1.Purpose:
Gene therapy seeks to correct or replace faulty genes that cause diseases. It aims to address the underlying genetic problems rather than just managing symptoms.

2.Methods:
Gene Replacement: Introducing a healthy copy of a gene to compensate for a defective or missing gene.
Gene Editing: Directly modifying or repairing the faulty genes in a patient's cells. Techniques like CRISPR/Cas9 are commonly used for this.
Gene Addition: Adding new genes into a patient’s cells to help fight or prevent disease.

3.Delivery:
Vectors: Genes are often delivered into cells using vectors, which are usually viruses modified to be harmless. These vectors carry the therapeutic gene into the patient’s cells.

4.Applications:
Genetic Disorders:Treating conditions caused by mutations in single genes, such as cystic fibrosis or muscular dystrophy.
Cancer:Introducing genes that help the immune system target and destroy cancer cells.
Infectious Diseases: Developing vaccines or treatments for diseases caused by viruses.
Example:
Inherited Blindness: For certain types of inherited blindness, gene therapy can involve introducing a normal copy of the gene responsible for vision into the retinal cells of the eye. This can help restore some degree of vision.

In summary, gene therapy is a groundbreaking approach to treating genetic disorders by directly modifying or replacing the genes responsible for the disease.

(b) Describe the procedure of such a therapy that could be a permanent cure for a genetic disease. Name the genetic disease.

Solution. Gene therapy can potentially offer a permanent cure for genetic diseases by correcting or replacing defective genes in a patient's cells. Here's a description of a typical procedure for gene therapy that could provide a lasting solution, using Cystic Fibrosis as an example.

Gene Therapy Procedure for Cystic Fibrosis:
1. Understanding Cystic Fibrosis:
Cause: Cystic Fibrosis (CF) is caused by mutations in the CFTR gene, which is crucial for regulating salt and water transport in and out of cells. This mutation leads to thick, sticky mucus in various organs, especially the lungs.
2. Designing the Therapy:
Gene Selection:The goal is to introduce a normal copy of the CFTR gene into the patient's cells. This normal gene can then produce functional CFTR proteins to replace the faulty ones.
3. Gene Delivery:
Vector Selection: A common method is to use a vector, typically a modified virus that can carry the normal CFTR gene into the patient's cells. The virus is engineered to be safe and non-infectious.
Vector Preparation: The vector is prepared by inserting the healthy CFTR gene into its genome.
4. Administering the Therapy:
Administration Methods: The gene therapy can be delivered to the patient through various methods:
Inhalation: For CF, the vector might be administered via an aerosol inhaler, which delivers it directly to the lungs where it needs to act.
Injection: In some cases, the vector might be injected directly into the bloodstream or into specific tissues.
5. Cellular Uptake:
Gene Transfer: The vector carries the normal CFTR gene into the cells lining the respiratory tract. Once inside, the gene is incorporated into the

cell's DNA or remains as an extra piece of genetic material, depending on the vector type.
6. Gene Expression:
Protein Production: The normal CFTR gene is transcribed and translated into the CFTR protein. This protein then helps in regulating the transport of salt and water, reducing the production of thick mucus.

7. Monitoring and Follow-up:
Effectiveness Monitoring: The patient's response to the therapy is monitored. This involves regular check-ups to assess improvements in lung function and overall health.
Long-Term Evaluation: Long-term effectiveness is evaluated, including checking for any potential side effects or issues with the stability of the introduced gene.
8. Potential Outcomes:
Permanent Cure: If successful, the therapy can provide a long-term or permanent cure by continuously producing the functional CFTR protein, improving the patient's symptoms and quality of life.
Summary:
Gene therapy for Cystic Fibrosis involves:
1. Identifying and preparing a normal CFTR gene.
2. Using a modified virus (vector) to deliver this gene into the patient's lung cells.
3.Enabling the cells to produce functional CFTR protein.
4.Monitoring the patient for effectiveness and any potential side effects.

By correcting the genetic defect responsible for the disease, this approach aims to provide a lasting solution and significant improvement in the patient's health.

Q.26. Differentiate between the explanations given by Darwin and de Vries respectively on the mechanism of evolution. Write any three differences.

Solution. Charles Darwin and Hugo de Vries offered distinct explanations for the mechanism of evolution. Here are three key differences between their views:

1.Mechanism of Evolution
Darwin:
Theory of Natural Selection: Darwin proposed that evolution occurs through natural selection. He argued that individuals with traits better suited to their environment are more likely to survive and reproduce, passing those advantageous traits to their offspring.
Gradual Change: Darwin believed that evolutionary changes are gradual and occur over long periods.

de Vries:
Theory of Mutation: De Vries introduced the concept of mutation as a primary mechanism of evolution. He suggested that new traits arise through sudden, discrete changes (mutations) in the genetic material, which can then be subject to natural selection.
Punctuated Change:** De Vries's approach implies that evolution can happen in bursts of rapid change rather than gradual, continuous processes.
2.Source of Variation
Darwin:
Variation Through Selection: Darwin posited that variation among individuals is continuous and arises from slight modifications over time. He believed that these variations are important for natural selection to act upon.
Adaptive Evolution:The continuous variations are subject to selection, and the beneficial ones are preserved.
de Vries:
Mutation as a Source: De Vries emphasised that new variations arise suddenly through mutations. He proposed that these mutations are the primary source of new traits and that they can lead to significant evolutionary changes.

Discrete Variation: De Vries's theory suggests that variations are more discrete and can cause significant changes rather than being gradual.

3.Role of Genetics
Darwin:
Pre-Mendelian Understanding: Darwin did not have a detailed understanding of genetics. His theory was based on observed variations and natural selection, but he lacked the genetic framework to explain how traits were inherited.
Blending Inheritance: Darwin's ideas were based on the concept of blending inheritance, where offspring were thought to be a mix of their parents' traits.

de Vries:
Genetics and Mutation: De Vries's work was informed by Mendelian genetics, which he used to explain how mutations can lead to new traits. His theory of mutations was a significant advance because it incorporated genetic principles.
Discrete Inheritance: De Vries's work supported the idea that traits are inherited in discrete units (genes), which can suddenly change due to mutations.
Summary:
1.Mechanism of Evolution: Darwin focused on gradual changes through natural selection, while de Vries emphasized sudden changes through mutations.
2.Source of Variation: Darwin believed in continuous variation subject to selection, while de Vries proposed discrete mutations as the main source of new traits.
3. Genetics: Darwin lacked a genetic framework, whereas de Vries integrated Mendelian genetics into his theory of evolution.

Q.28. (a) Name the enzyme responsible for the transcription of tRNA.

Solution. The enzyme responsible for the transcription of tRNA (transfer RNA) is RNA polymerase III.

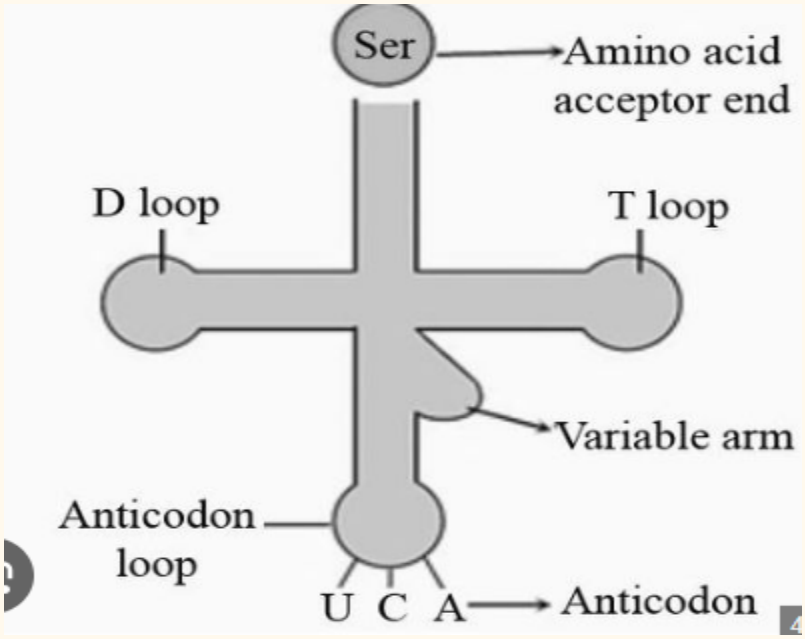
Explanation:
RNA Polymerase III: This enzyme is one of the three main types of RNA polymerases found in eukaryotic cells. Its primary function is to synthesise various types of small RNAs, including tRNA, 5S rRNA, and some other small non-coding RNAs.

Function: During the process of transcription, RNA polymerase III reads the DNA sequence and synthesises the corresponding tRNA molecule. This tRNA then plays a crucial role in translating the mRNA sequence into proteins by carrying specific amino acids to the ribosome.

So, RNA polymerase III is specifically responsible for the transcription of tRNA.

(b) Draw a labelled diagram of an initiator tRNA charged with its respective amino acid.

Solution.



(c) Explain the role of the initiator tRNA in initiation of protein synthesis.

Solution. The initiator tRNA plays a crucial role in the initiation phase of protein synthesis. Here's how it works:

Role of Initiator tRNA:

1. Binding to the Start Codon:
Initiation Process: Protein synthesis begins with the formation of the initiation complex on the ribosome. The initiator tRNA binds to the start codon on the mRNA sequence.
Start Codon: In eukaryotes, the start codon is typically AUG, which codes for the amino acid methionine. In prokaryotes, the start codon is also AUG, but the initiating amino acid is often a modified methionine called formylmethionine (fMet).

2.Formation of the Initiation Complex: Assembly: The initiator tRNA, carrying methionine (or fMet in prokaryotes), pairs with the start codon on the mRNA. This event occurs at the P site of the ribosome.
Ribosomal Subunits: The small ribosomal subunit first binds to the mRNA, then the initiator tRNA attaches to the start codon. Next, the large ribosomal subunit joins the complex, forming the complete ribosome ready for translation.
3.Facilitating Translation:
Amino Acid Addition: Once the initiator tRNA is in place, the ribosome is correctly positioned to start adding amino acids according to the mRNA sequence. This marks the transition from the initiation phase to the elongation phase of protein synthesis.

4.Correct Start of Translation Accuracy: The presence of the initiator tRNA ensures that translation starts at the correct location on the mRNA. This is crucial for producing the correct protein sequence and function.

Initiator tRNA is the specialised tRNA that binds to the start codon of the mRNA.
It carries the first amino acid (methionine or formylmethionine) and ensures the ribosome is properly positioned to start translating the mRNA into a protein.
Its binding marks the beginning of protein synthesis and sets the stage for the addition of subsequent amino acids.

In essence, the initiator tRNA is essential for accurately starting the process of translating genetic information into proteins.

SECTION D

Questions No. 29 and 30 are case-based questions. Each question has 3 sub-questions with internal choice in one sub-question.

29. Read the following passage and answer the questions that follow.
Restriction endonuclease was isolated for the first time by W. Arber in 1962, in bacteria. DNA, the genetic material can be manipulated by addition or substitution of the desired gene by using a specific restriction endonuclease resulting in rDNA. This is one of the major steps in biotechnology.

(a) Name the first isolated restriction endonuclease. Why are restriction endonucleases so called?

(b) Write the palindrome recognised by EcoRI.

(c) (i) How does restriction endonuclease function? Explain.
OR

(c) (ii) Write the convention for naming a restriction endonuclease with the help of an example.

Solution. (a) First Isolated Restriction Endonuclease: The first isolated restriction endonuclease was EcoRI.
Reason for the Name: Restriction endonucleases are so called because they "restrict" or cut DNA at specific sites. The term "endonuclease" reflects their ability to cleave DNA from within (endo-) the molecule at particular sequences.

(b) The palindrome sequence recognized by EcoRI is:
5'-GAATTC-3'
3'-CTTAAG-5'

(c) (i) Restriction endonucleases function by recognizing specific sequences of nucleotides in a DNA molecule and making cuts at these sites. Each restriction enzyme is specific to a particular DNA sequence, usually a palindromic sequence. Once the enzyme binds to its target sequence, it cleaves the DNA strand, which can result in either blunt or sticky ends. These cuts are crucial for various genetic manipulations, including cloning and gene editing.

(c) (ii) The naming convention for restriction endonucleases is as follows:
1. The first letter of the enzyme's name comes from the genus of the bacterium from which it was isolated.
2. The second letter comes from the species of the bacterium.
3. The third letter represents the strain of the bacterium.
4. A Roman numeral indicates the order of discovery of the enzyme in that particular strain.
Example: EcoRI
Eco: From Escherichia coli (genus and species)
R: Strain R
I: The first enzyme discovered in this strain

This naming system helps identify the origin and sequence of discovery of the enzyme.

Solution. (a) First Isolated Restriction Endonuclease: The first isolated restriction endonuclease was EcoRI.
Reason for the Name: Restriction endonucleases are so called because they "restrict" or cut DNA at specific sites. The term "endonuclease" reflects their ability to cleave DNA from within (endo-) the molecule at particular sequences.

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4. A Roman numeral indicates the order of discovery of the enzyme in that particular strain.
Example: EcoRI
Eco: From Escherichia coli (genus and species)
R: Strain R
I: The first enzyme discovered in this strain

This naming system helps identify the origin and sequence of discovery of the enzyme.

30. Read the following passage and answer the questions that follow.

A senior student, sneezing very badly, with watery eyes and having difficulty in breathing was brought to the school medical room by his fellow friends. The medical room nurse enquired as to what had happened. One of the students said "after the football match we all were sweating profusely, one of our friends sprayed deodorant on us. Soon after the deodorant was sprayed on the senior boy, the symptoms appeared."

(a) What are the symptoms seen in the student indicative of? Elaborate.

(b) State how the cause of such responses can be confirmed.

(c) (i) Name the cells in our body and the chemicals produced by them that are responsible for such reactions. Name any two drugs used to reduce these symptoms.
OR
(c) (ii) 'In recent times there is a rise in such reactions amongst urban human population.' Do you agree? Give three reasons in support of your answer.

Solution. (a) The symptoms described—sneezing, watery eyes, and difficulty in breathing—are indicative of an allergic reaction. Allergies occur when the immune system mistakenly identifies a harmless substance (in this case, deodorant) as a threat and mounts an immune response against it. This response involves the release of chemicals such as histamines, which cause inflammation and irritation in the respiratory tract, leading to the symptoms observed.

(b) The cause of such allergic responses can be confirmed through an allergy test. Common methods include:
Skin Prick Test: Small amounts of allergens are introduced into the skin via tiny pricks or scratches. If the person is allergic, a reaction like swelling or redness will occur at the test site.

Blood Test: Measures the presence of specific IgE antibodies in the blood that are produced in response to allergens.

These tests help identify specific allergens that trigger allergic reactions.

(c) (i) Cells and Chemicals: The cells responsible for allergic reactions are mast cells and basophils These cells produce and release histamines which are key in causing allergy symptoms such as sneezing, itching, and difficulty in breathing.
Drugs to Reduce Symptoms:
1. Antihistamines(e.g., cetirizine, loratadine) – They block the action of histamines and reduce allergic symptoms.
2.Corticosteroids (e.g., prednisone, fluticasone) – They reduce inflammation and suppress the immune response.
OR
(c) (ii) Yes, there is a rise in allergic reactions in urban populations. Three reasons supporting this observation include:

1. Increased Exposure to Pollutants: Urban environments often have higher levels of air pollution, which can exacerbate allergic reactions. Pollutants such as ozone and particulate matter can irritate the respiratory system and make individuals more susceptible to allergens.

2.Higher Use of Chemicals: Urban areas tend to have greater usage of various chemical products, including cleaning agents, deodorants, and perfumes. Frequent exposure to these chemicals can increase the likelihood of developing allergies or trigger allergic responses in susceptible individuals.

3. Changes in Lifestyle and Hygiene: Urban living often involves changes in lifestyle and hygiene practices. Overuse of antibiotics and a more sterile environment may affect immune system development and increase the risk of allergies. Additionally, less exposure to a variety of environmental factors and microbes during early childhood might affect the immune system's ability to respond to allergens properly.

SECTION E

Q.31. (a) Describe the process of wastewater (sewage) treatment under the following heads:
(i) Primary treatment
(ii) Secondary treatment

Solution. Wastewater Treatment Process

Wastewater treatment involves several stages to clean sewage before it is released back into the environment or reused. The process is generally divided into primary, secondary, and sometimes tertiary treatments. Let's focus on primary and secondary treatments.

(i) Primary Treatment

Objective: To remove large solids and particulate matter from wastewater.

Process:
1. Screening: Wastewater first passes through screens or grates that remove large objects like sticks, leaves, and plastic items.

2. Sedimentation: The wastewater then flows into a sedimentation tank or clarifier where the flow rate is reduced. This allows heavier solids, such as sand, grit, and organic matter, to settle at the bottom. These settled solids are called sludge.

3. Skimming: Lighter materials, such as oils and grease, float to the top and are skimmed off. This helps in removing floating debris and some organic material.

Outcome: The primary treatment reduces the amount of suspended solids and organic matter in the wastewater but does not significantly remove dissolved pollutants or harmful microorganisms.

(ii) Secondary Treatment

Objective:To further degrade and remove dissolved and suspended organic matter using biological processes.

Process:

1. Aeration: The partially treated water from the primary stage is introduced into an aeration tank. Here, it is mixed with air or oxygen, which encourages the growth of microorganisms (bacteria and protozoa). These microorganisms consume and break down the remaining organic matter.

2. Biological Filtration: Sometimes, secondary treatment includes biological filters or trickling filters, where wastewater is spread over a bed of materials (such as rocks or plastic media) covered with microorganisms. As the wastewater trickles through, the microorganisms digest the organic matter.

3.Secondary Clarification: After aeration or filtration, the wastewater is sent to a secondary clarifier. In this tank, the microorganisms and other particles that have formed during the treatment settle out. This results in a reduction of dissolved organic material.

4.Sludge Handling: The sludge (biomass) that settles out is collected and treated further, often through processes like digestion, dewatering, or composting. Some of the treated sludge may be returned to the aeration tank to maintain the microbial population.

Outcome: Secondary treatment significantly reduces the concentration of organic matter and pathogens in the wastewater, making it safer for discharge into natural water bodies or for further treatment and reuse.

OR

(b)(i) Explain the sequence of events occurring in a biogas plant.
(ii) Write the components of biogas.

(iii) Write any three advantages of using cow dung as the raw material.

Solution. Biogas Plant Sequence of Events

Biogas plants convert organic waste into biogas and digestate through a series of biological processes. Here's a step-by-step explanation of the sequence of events:

(i) Sequence of Events in a Biogas Plant**

1.Feedstock Collection:
Organic materials such as cow dung, agricultural residues, kitchen waste, and other biodegradable materials are collected and prepared. These materials are often chopped or shredded to increase their surface area for better digestion.

2. Loading into Digester:
The prepared organic waste is fed into an anaerobic digester, a sealed tank where the process takes place. The digester is typically an airtight chamber to ensure that the environment remains anaerobic (without oxygen).

3. Anaerobic Digestion:
Inside the digester, microorganisms break down the organic matter in the absence of oxygen. This process occurs in several stages:
Hydrolysis: Complex organic compounds like proteins, fats, and carbohydrates are broken down into simpler molecules.
Acidogenesis: Simple molecules are further broken down by acid-forming bacteria into volatile fatty acids, hydrogen, and carbon dioxide.
Acetogenesis: The fatty acids are converted into acetic acid, along with additional hydrogen and carbon dioxide.
Methanogenesis: Methane-forming bacteria convert acetic acid and hydrogen into methane (CH_4) and carbon dioxide (CO_2), producing biogas.

4.Biogas Collection:

The biogas, which is mainly methane and carbon dioxide, rises to the top of the digester and is collected through a gas outlet. This biogas can be used as a fuel for cooking, heating, or electricity generation.

5. Digestate Removal:
The remaining material, called digestate, is the solid and liquid residue left after digestion. This material can be removed from the digester and used as a nutrient-rich fertiliser for soil.

6.Post-Treatment:
In some plants, digestate undergoes further treatment, such as composting or dewatering, to enhance its quality and make it more suitable for agricultural use.
(ii) Components of Biogas
Biogas primarily consists of:
Methane (CH_4): Typically around 50-70% of biogas. Methane is the main component and the most valuable for energy production.
Carbon Dioxide (CO_2): Usually about 30-50% of biogas. It is a non-combustible gas.
Small amounts of other gases: This can include hydrogen (H_2), nitrogen (N_2), hydrogen sulphide (H_2S), and traces of other gases.

(iii) Advantages of Using Cow Dung as Raw Material

1. Abundant and Renewable Resource:
Cow dung is readily available, especially in agricultural areas where livestock is common. It is a renewable resource that can be continuously produced, making it a sustainable option for biogas production.

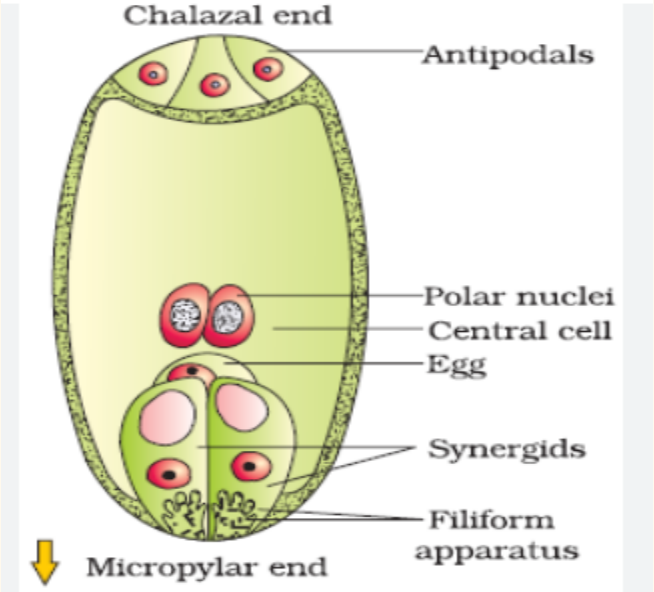
2.Nutrient-Rich Fertiliser:
The digestate (residual sludge) from a biogas plant, when using cow dung, is rich in nutrients like nitrogen, phosphorus, and potassium. It can be used as an effective organic fertiliser to improve soil fertility and support plant growth.

3. Reduces Waste and Pollution:
Utilising cow dung for biogas production helps manage and reduce agricultural waste. This process minimises the environmental pollution associated with open dung heaps, which can contribute to greenhouse gas emissions and groundwater contamination.

In summary, a biogas plant processes organic waste through anaerobic digestion to produce biogas and digestate. The biogas mainly contains methane and carbon dioxide, while cow dung as a raw material offers benefits like renewability, nutrient-rich fertiliser, and waste reduction.

Q.32.(a) (i) Draw a labelled diagram of a fertilised embryo sac of an angiosperm. (label any four parts)

Solution.



(ii) Explain double fertilisation in angiosperm plants.

Solution. Double fertilisation is a unique and essential process in angiosperm (flowering) plants that ensures the proper development of seeds. Here's a clear, step-by-step explanation of how it works:

1.Pollination: This is the first step, where pollen grains (which contain male gametes or sperm cells) are transferred from the anther (the male part of the flower) to the stigma (the female part of the flower).

2.Pollen Germination: After pollination, the pollen grain germinates on the stigma, growing a pollen tube down the style (the tube connecting the stigma to the ovary, where ovules are located).

3. Sperm Cell Movement: Within the pollen tube, two sperm cells travel towards the ovule. The ovule is housed inside the ovary of the flower.

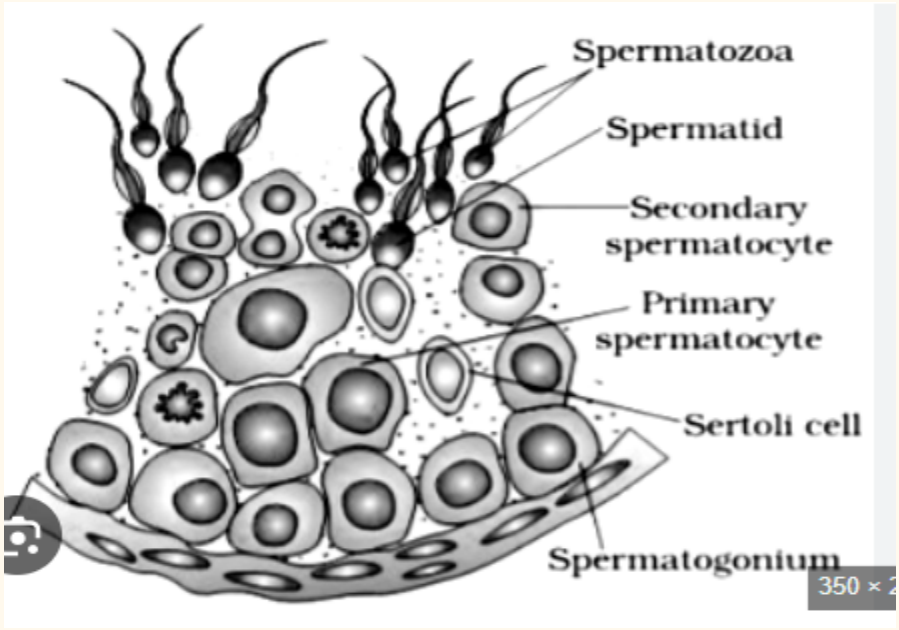
4.Fertilisation: Double fertilisation involves two separate fertilisation events within the ovule:
First Fertilisation: One sperm cell fuses with the egg cell (female gamete) to form a zygote. This zygote will eventually develop into the embryo of the seed.
Second Fertilisation: The other sperm cell fuses with two other cells in the ovule to form a triploid cell, which develops into the **endosperm**. The endosperm serves as the nutrient-rich tissue that nourishes the developing embryo within the seed.

5. Seed and Fruit Formation: After fertilisation, the ovule develops into a seed, and the surrounding ovary matures into a fruit. The endosperm provides essential nutrients to the growing embryo, ensuring that the seed has enough resources to germinate and grow into a new plant.

Double fertilisation is crucial because it ensures that the energy and resources of the plant are invested only in seeds that have been successfully fertilised, optimising reproductive efficiency and seed viability.

OR
(b)(i) Draw a labelled diagram of a cross-section of human seminiferous tubule. (label any four parts)

Solution.



(ii) Explain the hormonal regulation of spermatogenesis.

Solution. Spermatogenesis, the process by which sperm cells are produced in the testes, is regulated by hormones in a well-coordinated manner. Here's how hormonal regulation works in a clear, step-by-step manner:

1.Hypothalamus Releases GnRH: The process starts in the brain. The hypothalamus, a part of the brain, releases a hormone called gonadotropin-releasing hormone (GnRH) into the bloodstream.

2. GnRH Stimulates the Pituitary Gland: GnRH travels to the anterior pituitary gland (another part of the brain), prompting it to release two key hormones:
Luteinizing Hormone (LH): This hormone stimulates the Leydig cells in the testes to produce testosterone.
Follicle-Stimulating Hormone (FSH): FSH stimulates the Sertoli cells in the testes, which support and nourish the developing sperm cells.
3.Testosterone Production: LH stimulates the Leydig cells to produce testosterone, the primary male sex hormone. Testosterone is crucial for:
Promoting the development of sperm cells.

Regulating secondary sexual characteristics (e.g., facial hair, deep voice).
Providing negative feedback to the hypothalamus and pituitary gland.
4. Sertoli Cell Function: FSH acts on Sertoli cells, which are located within the seminiferous tubules of the testes. These cells:
Support and nourish developing sperm cells.
Produce androgen-binding protein (ABP), which binds to testosterone, concentrating it in the seminiferous tubules and facilitating spermatogenesis.
5.Feedback Mechanism: The levels of testosterone and sperm production are regulated through a feedback loop:
Negative Feedback: High levels of testosterone inhibit the release of GnRH from the hypothalamus and LH and FSH from the pituitary gland. This ensures that sperm production doesn't go into overdrive.
6.Completion of Spermatogenesis: Under the influence of testosterone and FSH, spermatogenesis progresses through several stages:
Spermatogonia (the starting germ cells) undergo mitosis and differentiation.
They form spermatocytes, which undergo meiosis to become spermatids.
Spermatids then mature into fully developed spermatozoa (sperm cells).

Q.33.(a) (i) Absence of lactose in the culture medium affects the expression of lac operon in E. coli. Why and how? Explain.

Solution. Solution. The lac operon in E. coli is a classic example of how bacteria regulate gene expression in response to environmental changes, such as the availability of lactose. Here's a straightforward explanation of how the absence of lactose affects the lac operon:

The Lac Operon Overview

The lac operon is a set of genes in E.coli that are responsible for the metabolism of lactose. It consists of:
1. LacZ: Encodes the enzyme β-galactosidase, which breaks down lactose into glucose and galactose.
2. LacY: Encodes the lactose permease, a protein that helps transport lactose into the cell.

3. LacA: Encodes the enzyme thiogalactoside transacetylase, which is involved in the lactose metabolism process.

These genes are regulated by two key elements:
The Promoter (P): Where RNA polymerase binds to start transcription.
The Operator (O): A DNA sequence where the repressor protein binds to block transcription.

Effect of Lactose Absence

When lactose is absent in the culture medium, the expression of the lac operon is affected as follows:

1.Repressor Protein Binding: In the absence of lactose, a protein called the lac repressor is produced. This repressor protein binds tightly to the operator region of the lac operon.

2. Blocking Transcription: When the repressor is bound to the operator, it physically blocks RNA polymerase from binding to the promoter. Without RNA polymerase, the genes of the lac operon cannot be transcribed into mRNA.

3. No Lactose Utilisation: Since the genes for lactose metabolism (lacZ, lacY, and lacA) are not expressed, E. coli cannot produce the enzymes needed to break down lactose. As a result, the bacterium conserves energy by not producing these enzymes when they are not needed.

Energy Efficiency: Synthesising the enzymes required for lactose metabolism uses energy and resources. By not producing them when lactose is not present, *E. coli* conserves energy and resources.

Inducible System: The lac operon is an inducible system, meaning it is turned on in the presence of lactose. The absence of lactose serves as a

signal for the bacterium to switch off the operon and avoid unnecessary production of enzymes.

In summary, when lactose is absent, the lac repressor binds to the operator of the lac operon, blocking RNA polymerase and preventing the transcription of genes necessary for lactose metabolism. This regulation ensures that E. coli only produces the enzymes needed for lactose breakdown when lactose is present, optimising resource use and energy efficiency.

(ii) Write any two ways in which the gene expression is regulated in eukaryotes.

Solution. Gene expression in eukaryotes is highly regulated to ensure that genes are turned on or off at the right times and in the right cells. Here are two key ways in which gene expression is regulated in eukaryotes:
1.Transcriptional Regulation
What It Is:
Transcriptional regulation controls the process of converting DNA into RNA. This is the first step in gene expression.
How It Works:
Promoters and Enhancers: Specific DNA sequences called promoters are located near the start of a gene and are crucial for initiating transcription. Enhancers are additional DNA sequences that can be located far from the gene they regulate. They help increase the transcription of specific genes by binding transcription factors (proteins that influence the transcription of genes).

Transcription Factors: These are proteins that bind to specific DNA sequences (promoters and enhancers) and either activate or repress the transcription of genes. Activators help recruit RNA polymerase to the promoter, while repressors inhibit this process.

Chromatin Remodelling: The structure of chromatin (the complex of DNA and proteins) can be modified to either expose or hide gene regions from

the transcription machinery. For instance, histone proteins can be chemically modified to make the chromatin more open (euchromatin) or more compact (heterochromatin), affecting gene accessibility.

Example:
The activation of the gene for globin (a protein in haemoglobin) in red blood cells is regulated by specific transcription factors that bind to enhancers near the globin gene, ensuring that the gene is expressed only in the appropriate cells.

2.Post-Transcriptional Regulation
Post-transcriptional regulation occurs after the RNA molecule has been synthesised and before it is translated into protein.
How It Works:
Alternative Splicing: During the processing of pre-mRNA, exons (coding regions) and introns (non-coding regions) are spliced out. Alternative splicing allows a single gene to produce multiple protein isoforms by including or excluding different exons. This process increases the diversity of proteins that can be produced from a single gene.
mRNA Stability and Degradation: The stability and lifespan of mRNA in the cytoplasm affect how much protein is produced. Certain molecules (e.g., microRNAs) can bind to mRNA and promote its degradation or inhibit its translation, thus regulating protein levels.

RNA Editing: This involves chemical modifications to RNA molecules that can alter their sequence and function. For example, specific nucleotides in the RNA can be edited to change the amino acid sequence of the resulting protein.

Example:
The regulation of the gene for the protein tropomyosin involves alternative splicing, where different splicing patterns result in various forms of tropomyosin that function differently in muscle cells and other tissues.

In summary, gene expression in eukaryotes is regulated through transcriptional mechanisms (such as promoters, enhancers, and chromatin remodelling) and post-transcriptional mechanisms (such as alternative splicing, mRNA stability, and RNA editing). These regulatory processes ensure precise control of gene expression in response to developmental and environmental signals.

OR

(b)(i) By taking two suitable traits in a pea plant, work out a dihybrid cross up to F2 generation.

Solution. To illustrate a dihybrid cross using pea plants, let's consider two traits: seed shape and seed colour. In pea plants, these traits are inherited independently according to Mendel's laws.

Traits and Alleles:
1. Seed Shape:
Round (R)is dominant.
Wrinkled (r) is recessive.

2.Seed Color:
Yellow (Y) is dominant.
Green (y) is recessive.

Step-by-Step Dihybrid Cross
1. P Generation (Parental Generation)
Let's start with two homozygous pea plants:
Plant 1: Round Yellow seeds (RRYY)
Plant 2: Wrinkled Green seeds (rryy)
Cross:RRYY x rryy

2. F1 Generation (First Filial Generation)

All offspring from this cross will be heterozygous for both traits:
Genotype:RrYy

Phenotype: Round Yellow seeds

So, every plant in the F1 generation will have the genotype RrYy and the phenotype Round Yellow.
3. F2 Generation (Second Filial Generation)

To determine the F2 generation, we need to cross two F1 individuals (RrYy x RrYy). We can use a Punnett square to visualise this.

Phenotypic Ratio:

From the Punnett square, the phenotypic ratio for the F2 generation will be:

Round Yellow (R_Y_): 9/16
Round Green (R_yy): 3/16
Wrinkled Yellow (rrY_): 3/16
Wrinkled Green (rryy): 1/16

Summary of Results
Round Yellow (dominant for both traits):9/16
Round Green (dominant for shape, recessive for colour): 3/16
Wrinkled Yellow (recessive for shape, dominant for colour): 3/16
Wrinkled Green (recessive for both traits): 1/16

This dihybrid cross demonstrates Mendel’s principle of independent assortment, where the inheritance of one trait (seed shape) does not influence the inheritance of another trait (seed colour).

(ii) State the Mendel's law derived from such a cross only.

Solution. The Mendelian law derived from a dihybrid cross, like the one involving seed shape and colour in pea plants, is known as Mendel's Law of Independent Assortment.
Mendel's Law of Independent Assortment

Definition:
This law states that the alleles for different traits (or genes) assort independently of one another into gametes. In other words, the inheritance of one trait (such as seed shape) does not affect the inheritance of another trait (such as seed colour).

How It Works:
During the formation of gametes (sperm and eggs), the alleles for each gene pair (e.g., seed shape and seed colour) segregate independently from each other.
This means that the allele a gamete receives for one gene does not influence the allele it receives for another gene.

Example from the Dihybrid Cross:
In the dihybrid cross between RrYy (round yellow) and RrYy (round yellow), the distribution of alleles for seed shape (R or r) is independent of the distribution of alleles for seed colour (Y or y). Thus, a gamete could carry any combination of these alleles (RY, Ry, rY, ry), and the combinations are produced independently of each other.

Phenotypic Ratio:
The independent assortment of these alleles results in the typical 9:3:3:1 phenotypic ratio in the F2 generation, demonstrating how the traits are inherited independently.

In summary, Mendel's Law of Independent Assortment is illustrated by the dihybrid cross, showing that different traits are inherited independently of each other.